

## **AMENDMENTS TO THE DRAWINGS**

Please add new FIG. 6. As this figure had previously been incorporated into the present specification by reference, no new matter is added.

## **REMARKS**

Favorable consideration of this Amendment is respectfully requested.

### **EXAMINER INTERVIEW**

The courtesy extended by the Examiner to one of the Applicants and the Applicants' representatives at the Interview on 26 April 2006 is greatly appreciated. Applicants appreciate that, after discussing the cited references, the Examiner indicated that the claims would be given favorable consideration if Applicants amend the independent claims to include accounting for dielectric properties and amending the specification to include information from a co-pending application that was incorporated into the present specification by reference.

### **AMENDMENTS TO THE SPECIFICATION**

As advised by the Examiner in the interview, Applicants have added several paragraphs and a new figure to the specification. The subject matter of these new paragraphs were previously included in the specification as-filed by incorporation by reference on page 12, lines 21-24 to co-pending application since published as U.S. Patent Publication No. US 2005-0118468 entitled "Fuel Cell System Including Information Storage Device and Control System". Applicants note further that calibration curves are discussed in the present specification on pages 8-10 thereof. As such, no new matter has been added, and Applicants respectfully request that the amendments be entered.

### **AMENDMENTS TO THE CLAIMS**

Claims 1-11, 28-47 and 53-59 are pending in the application, with claims 1 and 36 being the independent claims. Claims 12-27 and 48-52 were previously cancelled and claim 60 is presently canceled without prejudice to or disclaimer of the subject matter therein. In response to the election of species, claims 3-11, 37, 38, 41, 42, 44 and 45 are withdrawn from consideration pending the allowance of generic claims 1 and 36. The amendments to the claims and the remarks herein reflect the discussion and conclusions reached in the 26 April 2006 Interview. No new matter has been added by these amendments, and Applicants respectfully request their entry into the record of the above-captioned application.

Claims 1, 2, 28-31, 36, 39, 40, 43, 46, 47, 53-55 and 60 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Pat. Appl. Pub. 2003/0129464 to Becerra *et al.* in view of U.S. Patent 6,641,240 to Hsu *et al.* (Final Office Action at p. 3.) In this group of claims, claims 1, 36 and 60 are the independent claims. Applicants respectfully assert that as amended, each of the independent claims is patentable over the combination of Becerra *et al.* and Hsu *et al.*

The Examiner suggests in the Final Office Action that there is no change in functionality when the non-moving sensor is moved from the ink supply to the fuel cell or electronic equipment. As discussed in the 26 April 2006 Interview, Applicants respectfully disagree with this suggestion. Due to the significant difference between dielectric constants, having the outer shell and the liner, as well as the fuel, between the sensors or plates can significantly change the characteristics and functionality of the capacitance therebetween. As disclosed in the present specification from page 8, line 31 to page 9, line 2, when the second sensor is located on the fuel cell/electronic equipment, the aggregate dielectric constant of the outer shell of the fuel cartridge and the liner, in addition to the dielectric constant of the fuel, have to be taken into consideration.

As discussed in the 26 April 2006 Interview, Applicants believe that the capacitance of multiple layers of materials is most analogous to capacitors in series in a circuit. The capacitance of a parallel plate capacitor is given by the following well-known equation, as described at [http://webphysics.davidson.edu/physlet\\_resources/bu\\_semester2/c08\\_dielectric\\_constant.html](http://webphysics.davidson.edu/physlet_resources/bu_semester2/c08_dielectric_constant.html), a print-out of which is attached hereto as Appendix A:

$$C = \kappa \epsilon_0 A / d$$

where C is the capacitance in Farads,  $\kappa$  is the dielectric constant,  $\epsilon_0$  is the permittivity of a vacuum, A is the area of plate overlap in square meters, and d is the distance between the plates in meters.

In series, the total capacitance,  $C_{\text{total}}$ , of a system is determined by the following equation, as described at [http://www.ibiblio.org/obp/electricCircuits/DC/DC\\_13.html](http://www.ibiblio.org/obp/electricCircuits/DC/DC_13.html), a print-out of selected portions of which is attached hereto as Appendix B:

$$C_{\text{total}} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}}$$

As such, introducing additional dielectric constants to the system vastly increases the complexity of determining the total capacitance thereof. For example, the dielectric constant for methanol is 33 and for water is 80, while the dielectric constant for the outer shell, which can be plastics, are on average about 2.3 or 2.4 for LDPE/HDPE and ABS, about 3.7 for acetyl, 6-9 for neoprene and even about 64 for nylon. However, due to differences in manufacturing processes and tolerances, the actual dielectric constant of the outer shell material, the liner material, or even the fuel can vary widely. To have the outer shell, the liner, any overlapping portions of liner due to an uneven collapsing thereof, an air gap between the liner and the outer shell, and/or any air pockets trapped within the fuel due to, for example, uneven collapsing of the liner intervene between the plates/sensors could significantly alter the aggregate dielectric constant between the plates/sensors. As discussed in the 26 April 2006 Interview and in the Applicants' specification on pages 8-9 and 12 *et seq.*, information for each cartridge, such as "manufacturing information", "materials used in manufacturing", and "fuel gauge type", can be stored on the cartridge, the fuel cell, and/or the electronic device powered by the fuel cell in an information storage device such as an EEPROM, bar codes, *inter alia*. The information storage device provides information relative to the cartridge, allowing the cartridge to specify the precise materials and dimensions included when a new cartridge is inserted into a fuel cell system, so that an accurate dielectric constant may be determined in order to calibrate the fuel gauge sensor system. Alternatively, calibrating curves, discussed on pages 8-10 of the present specification can also be used to measure the remaining fuel.

In contrast, both the Becerra *et al.* and Hsu *et al.* references are silent on moving a sensor to the fuel cell at all. Additionally, as disclosed in FIGS. 2A and 7A and in column 4, lines 1-4 of the Hsu *et al.* reference, only the ink is disposed between the two electrode plates. Becerra *et al.* and Hsu *et al.* are completely silent on the complicated aspect of how to calibrate sensor systems for use with fuel cell fuel supply cartridges, and, thus, do not provide any means for accounting for the combined dielectrics; the only disclosure related to this is from Applicant's own specification. For this reason, one of ordinary skill in the art in a hypothetical combination of Becerra *et al.* and Hsu *et al.* would not move the non-moving sensor or plate from the ink supply from Hsu *et al.* to the fuel cell, because it is more difficult to control and no way of appropriately calibrating the sensors is provided in the cited references.

As such, Applicants believe that all of the Examiner's rationales supporting the rejection of independent claims 1 and 36 have been fully addressed, and that these claims as amended are patentable over the cited art of record. The allowance of claims 1 and 36 is earnestly solicited.

Claims 2 and 28-31 depend from and add further features to independent claim 1 and claims 39, 40, 43, 46, 47, and 53-55, depend from and add further features to independent claim 36 and are patentable over this combination of references for this reason alone. While it is not necessary to address the Examiner's rejections of these claims at this time, Applicants reserve the right to support their patentability, when necessary.

Claims 32-35 and 56-59 are rejected under 35 U.S.C. §103(a) as being unpatentable over the combination of Becerra and Hsu as applied to claims 1 and 36 above, and further in view of U.S. Pat. Appl. Pub. No. 2003/0006245 to Rodgers and U.S. Patent No. 5,816,224 to Welsh *et al.* As discussed above, claims 1 and 36 are patentable over the Becerra *et al.* and Hsu *et al.* references. As previously discussed, the Rodgers and Welsh *et al.* secondary references do not make up for the deficiencies in the primary references. Claims 32-35 and 56-59 depend from and add further features to claims 1 and 36 and are patentable over this combination of references for this reason alone.

**RESTRICTION REQUIREMENT SHOULD BE LIFTED**

Further, as generic claims 1 and 36 are now allowable, Applicants respectfully request that the Restriction Requirement be lifted, the withdrawn claims be considered in the present application, and amendments to the withdrawn claims be permitted so as to reflect the amendments to the generic claims.

**CONCLUSION**

All of the stated grounds of objection and rejection have been properly traversed, accommodated, or rendered moot. Applicants therefore respectfully request that the Examiner reconsider all presently outstanding objections and rejections and that they be withdrawn. Applicants believe that a full and complete reply has been made to the outstanding Office Action and, as such, the present application is in condition for allowance.

If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

It is not believed that extensions of time or fees for net addition of claims are required beyond those that may otherwise be provided for in documents accompanying this paper. However, if additional extensions of time are necessary to prevent abandonment of this application, then such extensions of time are hereby petitioned under 37 C.F.R. § 1.136(a), and any fees required therefore (including fees for net addition of claims) are hereby authorized to be charged to The H.T. Than Law Group, Deposit Account No. 50-1980.

Respectfully submitted,

Date: May 1, 2006



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## APPENDIX A

### The Dielectric Constant

How effective a dielectric is at allowing a capacitor to store more charge depends on the material the dielectric is made from. Every material has a dielectric constant  $\kappa$ . This is the ratio of the field without the dielectric ( $E_0$ ) to the net field ( $E$ ) with the dielectric:

$$\kappa = E_0/E$$

$E$  is always less than or equal to  $E_0$ , so the dielectric constant is greater than or equal to 1. The larger the dielectric constant, the more charge can be stored.

Completely filling the space between capacitor plates with a dielectric increases the capacitance by a factor of the dielectric constant:

$C = \kappa C_0$ , where  $C_0$  is the capacitance with no dielectric between the plates.

For a parallel-plate capacitor containing a dielectric that completely fills the space between the plates, the capacitance is given by:

$$C = \kappa \epsilon_0 A / d$$

The capacitance is maximized if the dielectric constant is maximized, and the capacitor plates have large area and are placed as close together as possible.

If a metal was used for the dielectric instead of an insulator the field inside the metal would be zero, corresponding to an infinite dielectric constant. The dielectric usually fills the entire space between the capacitor plates, however, and if a metal did that it would short out the capacitor - that's why insulators are used instead.

Material	Dielectric constant	Dielectric Strength (kV/mm)
Vacuum	1.00000	-
Air (dry)	1.00059	3
Polystyrene	2.6	24
Paper	3.6	16
Water	80	-

From [http://webphysics.davidson.edu/physlet\\_resources/bu\\_semester2/c08\\_dielectric\\_constant.html](http://webphysics.davidson.edu/physlet_resources/bu_semester2/c08_dielectric_constant.html)  
(last visited April 27, 2006)

## APPENDIX B

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### Lessons In Electric Circuits -- Volume I

### Chapter 13

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#### CAPACITORS

- Factors affecting capacitance
  - Series and parallel capacitors
  - Contributors
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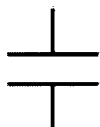
#### Factors affecting capacitance

There are three basic factors of capacitor construction determining the amount of capacitance created. These factors all dictate capacitance by affecting how much electric field flux (relative difference of electrons between plates) will develop for a given amount of electric field force (voltage between the two plates):

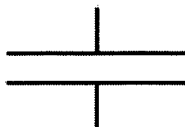
**PLATE AREA:** All other factors being equal, greater plate area gives greater capacitance; less plate area gives less capacitance.

*Explanation:* Larger plate area results in more field flux (charge collected on the plates) for a given field force (voltage across the plates).

less capacitance



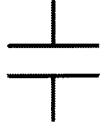
more capacitance



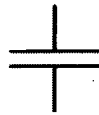
**PLATE SPACING:** All other factors being equal, further plate spacing gives less capacitance; closer plate spacing gives greater capacitance.

*Explanation:* Closer spacing results in a greater field force (voltage across the capacitor divided by the distance between the plates), which results in a greater field flux (charge collected on the plates) for any given voltage applied across the plates.

less capacitance



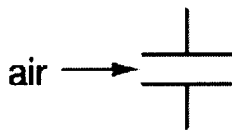
more capacitance



**DIELECTRIC MATERIAL:** All other factors being equal, greater permittivity of the dielectric gives greater capacitance; less permittivity of the dielectric gives less capacitance.

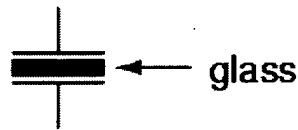
*Explanation:* Although it's complicated to explain, some materials offer less opposition to field flux for a given amount of field force. Materials with a greater permittivity allow for more field flux (offer less opposition), and thus a greater collected charge, for any given amount of field force (applied voltage).

less capacitance



(relative permittivity  
= 1.0006)

more capacitance



(relative permittivity  
= 7.0)

"Relative" permittivity means the permittivity of a material, relative to that of a pure vacuum. The greater the number, the greater the permittivity of the material. Glass, for instance, with a relative permittivity of 7, has seven times the permittivity of a pure vacuum, and consequently will allow for the establishment of an electric field flux seven times stronger than that of a vacuum, all other factors being equal.

The following is a table listing the relative permittivities (also known as the "dielectric constant") of various common substances:

Material	Relative permittivity (dielectric constant)
Vacuum	1.0000
Air	1.0006

PTFE, FEP ("Teflon") -----	2.0
Polypropylene -----	2.20 to 2.28
ABS resin -----	2.4 to 3.2
Polystyrene -----	2.45 to 4.0
Waxed paper -----	2.5
Transformer oil -----	2.5 to 4
Hard Rubber -----	2.5 to 4.80
Wood (Oak) -----	3.3
Silicones -----	3.4 to 4.3
Bakelite -----	3.5 to 6.0
Quartz, fused -----	3.8
Wood (Maple) -----	4.4
Glass -----	4.9 to 7.5
Castor oil -----	5.0
Wood (Birch) -----	5.2
Mica, muscovite -----	5.0 to 8.7
Glass-bonded mica -----	6.3 to 9.3
Porcelain, Steatite -----	6.5
Alumina -----	8.0 to 10.0
Distilled water -----	80.0
Barium-strontium-titanite -----	7500

An approximation of capacitance for any pair of separated conductors can be found with this formula:

$$C = \frac{\epsilon A}{d}$$

Where,

**C = Capacitance in Farads**

**$\epsilon$  = Permittivity of dielectric (absolute, not relative)**

**A = Area of plate overlap in square meters**

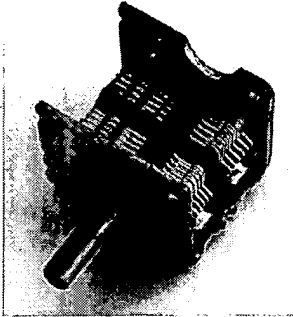
**d = Distance between plates in meters**

A capacitor can be made variable rather than fixed in value by varying any of the physical factors determining capacitance. One relatively easy factor to vary in capacitor construction is that of plate area, or more properly, the amount of plate overlap.

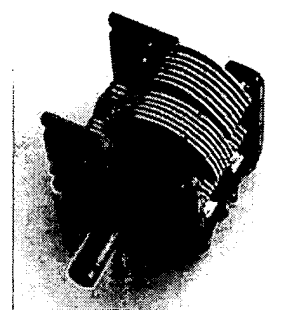
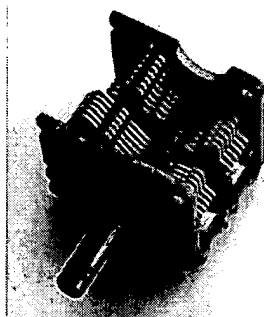
The following photograph shows an example of a variable capacitor using a set of interleaved metal plates and an air gap as the dielectric material:

#### A VARIABLE CAPACITOR (AIR DIELECTRIC)

Maximum plate overlap:  
maximum capacitance



Minimum plate overlap:  
minimum capacitance

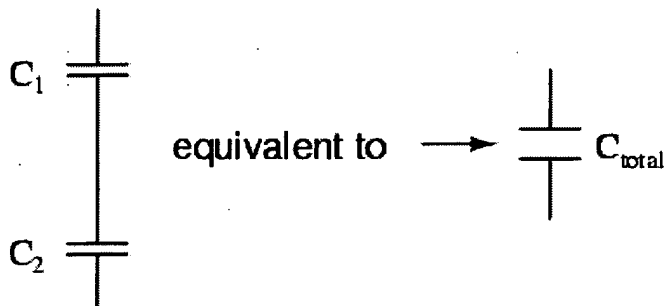


As the shaft is rotated, the degree to which the sets of plates overlap each other will vary, changing the effective area of the plates between which a concentrated electric field can be established. This particular capacitor has a capacitance in the picofarad range, and finds use in radio circuitry.

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### Series and parallel capacitors

When capacitors are connected in series, the total capacitance is less than any one of the series capacitors' individual capacitances. If two or more capacitors are connected in series, the overall effect is that of a single (equivalent) capacitor having the sum total of the plate spacings of the individual capacitors. As we've just seen, an increase in plate spacing, with all other factors unchanged, results in decreased capacitance.

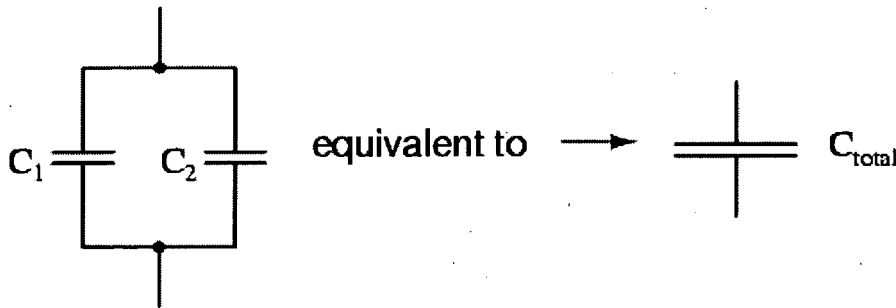


Thus, the total capacitance is less than any one of the individual capacitors' capacitances. The formula for calculating the series total capacitance is the same form as for calculating parallel resistances:

### *Series Capacitances*

$$C_{\text{total}} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}}$$

When capacitors are connected in parallel, the total capacitance is the sum of the individual capacitors' capacitances. If two or more capacitors are connected in parallel, the overall effect is that of a single equivalent capacitor having the sum total of the plate areas of the individual capacitors. As we've just seen, an increase in plate area, with all other factors unchanged, results in increased capacitance.



Thus, the total capacitance is more than any one of the individual capacitors' capacitances. The formula for calculating the parallel total capacitance is the same form as for calculating series resistances:

### *Parallel Capacitances*

$$C_{\text{total}} = C_1 + C_2 + \dots + C_n$$

As you will no doubt notice, this is exactly opposite of the phenomenon exhibited by resistors. With resistors, series connections result in additive values while parallel connections result in diminished values. With capacitors, it's the reverse: parallel connections result in additive values while series connections result in diminished values.

- **REVIEW:**
- Capacitances diminish in series.
- Capacitances add in parallel.

## **Contributors**

Contributors to this chapter are listed in chronological order of their contributions, from most recent to first. See Appendix 2 (Contributor List) for dates and contact information.

**Warren Young** (August 2002): Photographs of different capacitor types.

**Jason Starck** (June 2000): HTML document formatting, which led to a much better-looking second edition.

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